Title
Multifactorial Analysis of Implant Removal - A Retrospective Study of 19 year data

Author
Petrovska, Anastasiya

Publication Date
2020

Peer reviewed|Thesis/dissertation

Multifactorial Analysis of Implant Removal- A Retrospective Study of 19 year data

by
Anastasiya Petrovska

THESIS
Submitted in partial satisfaction of the requirements for degree of
MASTER OF SCIENCE

in

Oral and Craniofacial Sciences

in the

GRADUATE DIVISION
of the
UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

Approved:

DocuSigned by:
Yvonne Kapila
CE032F3A4E984CF...

Yvonne Kapila

Chair

DocuSigned by:
PINELOPI XENOUDI
DocuSigned by:
Yogalakshmi Rajendran
7478C3EBE4A74BB...

PINELOPI XENOUDI

Yogalakshmi Rajendran

Committee Members

Acknowledgements

Division of Periodontology and Department of Orofacia Sciences at University of California, San Francisco

Committee in Charge: Dr. Yvonne Kapila, Dr. Pinelopi Xenoudi, Dr.Yogalakshmi Rajendran for their continued support and guidance.

Haripriya Padma, Mohammed Feizizad, Sameer Bajaj, Sakshi Kapoor for their contribution to the project.

Abstract

Multifactorial Analysis of Implant Removal - A Retrospective Study of 19 year data

Anastasiya Petrovska

Introduction: Dental implants have become a popular choice for replacing missing teeth. It is estimated that every year, over two million implants are placed throughout the world. However, dental implants may exhibit immediate or delayed complications that could lead to implant failure. The aim of this study was to explore the factors coincidental with removal of failed implants at the UCSF Postgraduate Periodontology Clinic (PGPC) by reviewing electronic health records (EHR) for the last 19 years.

Methods: EHR data from Axium were searched for the dental code D6100 (implant removal) from January 2001 – April 2019. Furthermore, code D7140 (simple tooth removal) was used to include cases that were suspected to be misclassified. Inclusion criteria was focused on patients who had dental implant(s) removed and had sufficient records for analysis. Patient and surgical data were gathered from dental records and analyzed. Exclusion criteria focused on patient data that was incomplete or not accessible.

Results: Upon review of 3,426 simple tooth extractions and 81 implant explantations, it was determined that 114 implants were explanted from 88 patients over 19 years. Fifteen patients were removed from the data analysis based on exclusion criteria. Analysis was performed on 73 patients who had a total of 96 implants removed. Of these, 59% of patients had periodontal disease and 32% were smokers. Amongst the medical conditions reviewed, 32% of patients reported cardiovascular disease, 23% had a bone disorder, and 18% had emotional disorders. In terms of the implants, 41 implants were placed in grafted bone; 54% being allograft. Out of 96

implants removed, 58 were late failures and 33 implants failed before loading. Furthermore, we examined the reasons for tooth extractions at sites with subsequent implant failure and found that 6 teeth had endodontic treatment and 3/6 had periapical abscesses. Forty-five percent of cases that had a late failure did not report regular recall and maintenance appointments.

Conclusion: Implant failure was coincidental with a history of periodontal disease and other risk factors, such as cardiovascular disease and emotional disorders. A lack of consistent maintenance recalls was frequently found in cases with late implant failure. Not every patient is a good candidate for implant therapy and risk factors have to be carefully evaluated and presented to the patient. This research highlights the need for a systematic evaluation of patients planning to receive implants and the need to inform them of possible complications and risks of implant treatment.

Table Of Contents

List of Figures

List of Tables

Introduction

Dental implants are a successful treatment option for replacing missing teeth. It is estimated that every year, five million dental implants are placed in the United States. Dental implants treat edentulous spaces without damaging the adjacent teeth and restore patients' chewing ability and esthetics. Implants are a great option for most patients, and they have a high success rate for treating failed teeth and edentulous areas.

High survival and success rates are reported in the literature, all ranging in the high 90 percent (Moraschini, 2015; Berglundh, 2002; Pjetursson, 2004). If compared to other alternative treatments, Fugazzotto et al. reported 97 - 98.6 % success rate for implants in molar sites, with the lowest success rate being that of second molar sites (85%) in comparison to root resection. Fixed partial dentures have a success rate of 93.67% over 6-7 years compared to single crown implants, which have a long-term success rate of 97.5% (Fugazzotto, 2001).

A major reason for the high success rates of dental implants is the biocompatibility of titanium fixtures with human bone and the ability of dental implants to osseointegrate. The concept of osseointegration was first coined by Branamark et al. and was described as bone -to-implant contact at the light microscopic level (Branamark, 1969). Alberktsson and Sennerby then defined osseointegration as "a direct functional and structural connection between living bone and the surface of a load carrying implant" (Alberktsson, 1991). A histological connection between new bone and the implant surface is established as early as 6 weeks and is 60% mature at three months (Berglundh, 2003). If such healing is not successful, early implant failure occurs, even prior to an implant being restored and loaded.

Similar to periodontal health, dental implant success relies on bone and soft tissue health. Peri-implant tissues are those that support the osseointegrated implant – soft and hard tissue

(Karoussis, 2007). The American Academy of Periodontology defines two diseases that could affect implants, peri-implant mucositis and per-implantitis (Lang, 2011; Schwarz, 2018). Peri-implant mucositis includes inflammation of the soft tissues surrounding a dental implant without additional bone loss after the initial bone remodeling. This disease is considered reversible with proper treatment (Salvi, 2012; Meyer, 2017). Peri-implantitis is characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone. This disease process could lead to implant failure and the need for implant removal. The increasing prevalence of peri-implantitis underscores the need to explore the risk factors associated with implant failure. Studies have reported several risk indicators for developing peri-implant disease; the most prevalent being a history of periodontal disease, poor oral hygiene, and smoking and diabetes. (Heitz-Mayfield, 2008). The purpose of this retrospective study was to explore the factors coincidental with implant removal at the UCSF postgraduate periodontology clinic by reviewing the EHR for the last 19 years.

Methods

This study was reviewed and approved by the UCSF Institutional Review Board (Approval # ID- 17-22729). Electronic health records from the school's dental database (Axium software, Dentrix) were accessed for current dental terminology (CDT) codes D6100 (implant removal) and D7140 (simple tooth extraction) from January 2001 to April 2019. Data were collected from patients who had one or more implant removed in the Post-Graduate and Faculty Periodontal clinic, regardless of whether or not the implant was originally placed at UCSF. Exclusion criteria included, incomplete or non-accessible data. Data, including age at the time of removal, gender, and all available medical, dental, and social history were collected from

patients' records. History of periodontal disease was determined based on previous non-surgical and surgical periodontal treatment. In addition, surgery and implant details, follow-up, and maintenance schedules were obtained from the electronic dental records where available. [Basic statistical analysis was performed on the collected data.

Results

Patient Demographics and Implant Failures

The search and review of the records resulted in the selection of 87 patients who had a total of 114 implants removed. In addition, 15 patients were excluded based on incomplete data. Also, two implants were incorrectly classified as simple tooth extractions in one patient. Therefore, the statistical analysis was performed on data from 73 patients and 96 implants.

The youngest patient who had an implant removed was 28 and the oldest 88 years old, with an average age of 62 years old at the time of implant removal. Thirty-eight male patients, 34 female patients, and one transgender patient were included in the analysis (**Table 1**). Sixteen patients experienced multiple implant failures; the highest number of implants removed was five in one patient, but two of the implants were repeat failures in the same sites. Fifty-seven patients had one implant removed during the investigation time frame.

Table 1: Descriptive analysis of the examined patient population and implant removal.

Demographic Data	Number of Patients
Total number of patients	73
Age at the time of explantation	
Under 30	1
30 - 50	17
51 - 65	19
66-75	30
76 and over	6
Gender	
Male	38
Female	34
Transgender	1
Number of implants removed	
1	57
2	10
3	5
4	0
5	1
Total Number of implants	96

Fifty patients had implants placed at UCSF, and 46 were placed in outside clinics. Out of 96 implants, 58 (61%) were restored and had one to fifteen years of service before failure. 33 (34%) exhibited early failure (**Figure 1**). For 5 (5%) implants it was unclear whether they were restored at the time of failure. Four early-failure implants developed a buccal fistula and radiolucency a few weeks following placement, two of which report previous endodontic infection on the site (**Table 2**). The rest of the implants had inadequate osseointegration prior to or at second-stage surgery. Late failures were primarily associated with advanced peri-implant disease (54/58), implant fracture (2/58), periapical abscess and pain (2/58).

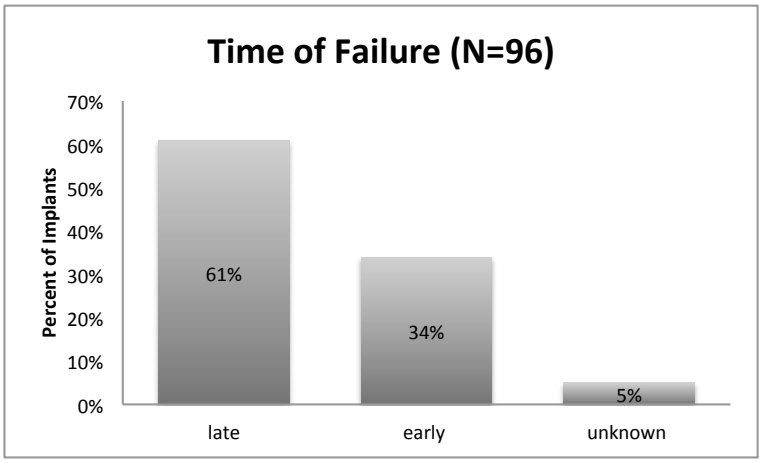

Figure 1: Percentile Distribution of early and late implant failures based on total number of implants removed

Table 2: Reported causes of implant removal based on the timing of failure.

Reasons for Implant Removal	Percent of Implants
Early Failure	34%
Mobility, failure to integrate	20%
Abscess	4%
Extensive Bone Loss	3%
Unrestorable Position	1%
Late Failure (1-15 years)	61%
Peri - implantitis (bone loss, mobil	54%
Abcess	4%
Fracture of the fixture	2%

Medical and Social History

Amongst the medical conditions reviewed, most prominent was a history of cardiovascular disease at 32%. Bone disease was reported in 23% of patients; one patient reported taking an oral bisphosphonate for osteoporosis (**Figure 2**). Eighteen percent of patients presented with emotional disorders, such as depression, anxiety, and post traumatic stress disorder. Sixteen percent of patients reported having acid reflux or gastroesophageal reflux disease (GERD), and 15% had a respiratory condition, such as asthma, chronic obstructive pulmonary disease (COPD), or emphysema. Eight patients had a history of cancer and 7 patients

reported a viral infectious disease (human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) or hepatitis B).

Fourteen percent of patients presented with a diagnosis of diabetes. One patient had Type 1 diabetes and the remaining patients had Type 2. Patients reported taking medications for their diabetes and were determined to have a normal or stable HbA1c measurements as recorded in their electronic dental records.

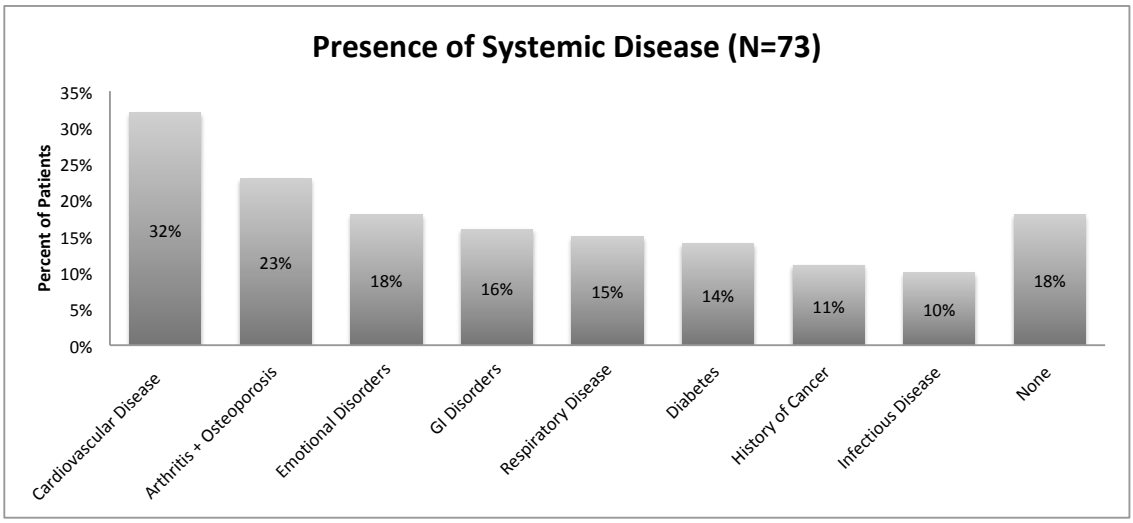

Figure 2: Percent distribution of the systemic diseases reported in patients' charts coincidental with implant removal.

Thirty-two percent of patients reported using tobacco products currently or in the past (Figure 3). However, it was not possible to determine the breakdown of products used.

Thirteen patients had no significant medical or social history.

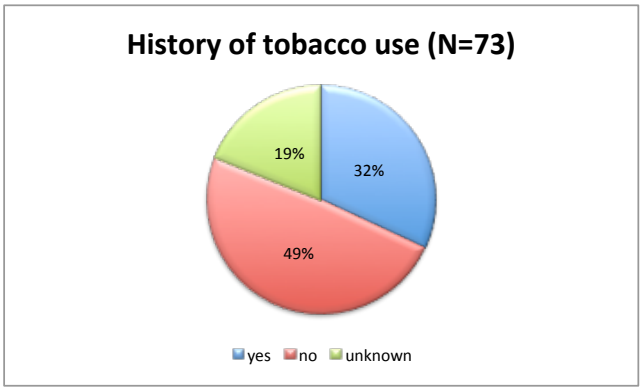

Figure 3: History or current use of tobacco products in patients that underwent explantation procedure.

Dental History

A history of periodontal disease was present in 59% of patients based on a recorded history of surgical or non-surgical periodontal treatment (**Figure 4**). Oral habits and occlusal schemes were not clearly reported in the electronic dental records.

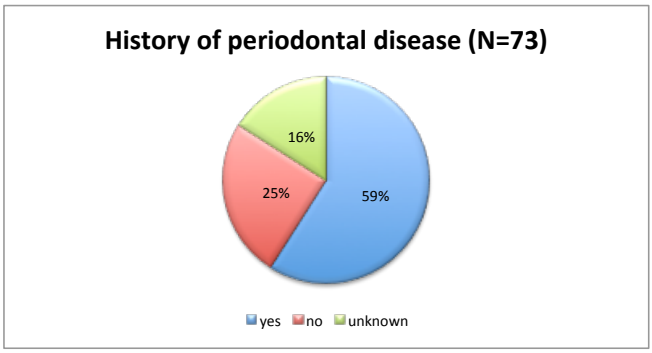

Figure 4: Presence or history of periodontal disease in patient population determined by the history of previous periodontal treatment or established diagnosis.

Examination of the reason for tooth removal at sites where implants failed revealed that 5 (15%) teeth had endodontic treatment and 3 out of these 5 (5%) had periapical abscesses (**Figure 5**). Also, teeth were removed due to severe periodontal disease and unrestorable conditions.

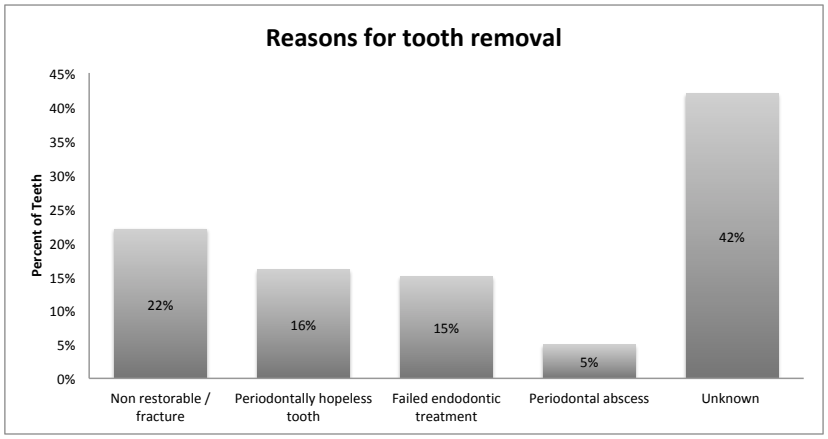

Figure 5: Causes of the tooth failure in site where the implant was placed with subsequent failure.

Surgery and Maintenance

It was determined that 41 (43%) failed implants were placed in grafted bone and underwent either ridge preservation, guided tissue regeneration, sinus augmentation, simultaneous augmentation or a combination thereof (**Figure 6**). The majority of cases (54%) used particulate allograft for bone augmentation (**Figure 7**). Other cases used a mixture of allograft and autogenous graft, or allograft and xenograft, 12% and 10% respectively. Other materials were used to a lesser extent.

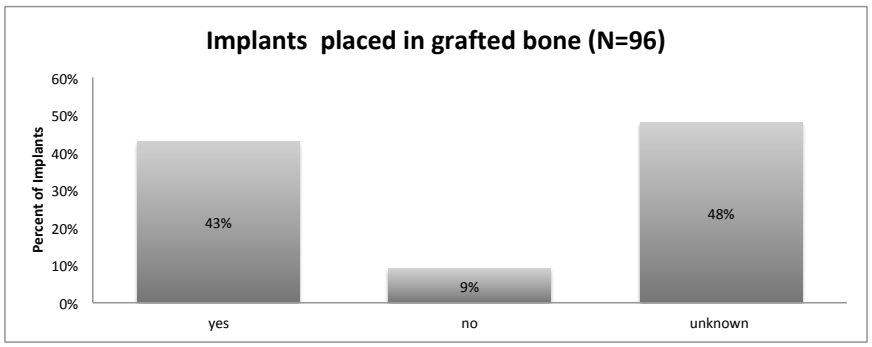

Figure 6: Number of implants that were placed in any kind of grafted site for various procedures: ridge preservation, ridge augmentation, sinus augmentation.

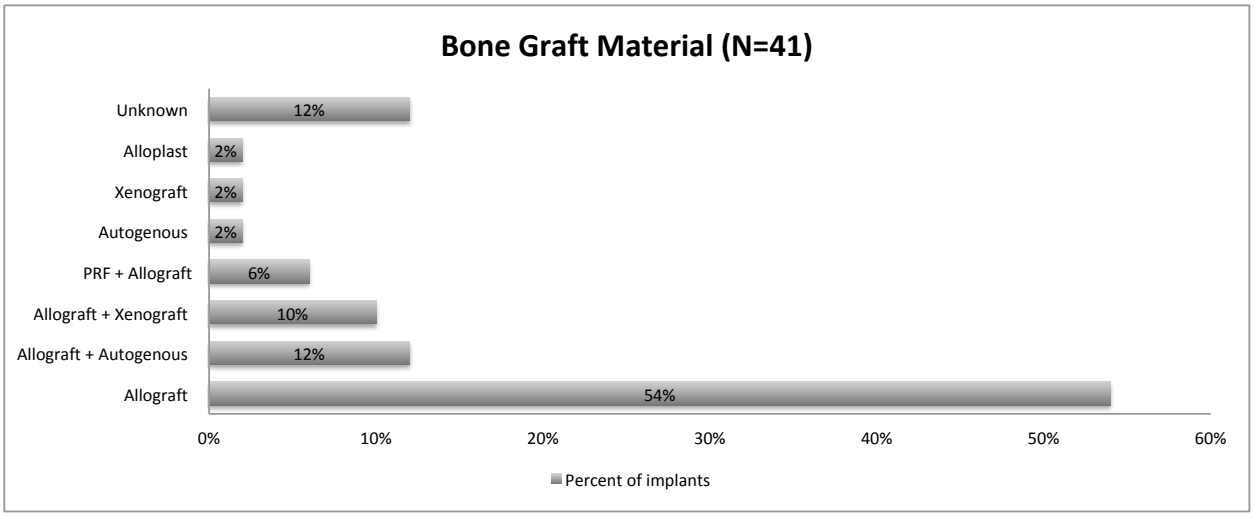

Figure 7: The source of the grafted material that was used in the above augmentation procedures.

Various implant systems were represented in the failed implants. The highest number of failed implants were Nobel Biocare (31%) followed by unknown types (30%) (**Figure 8**).

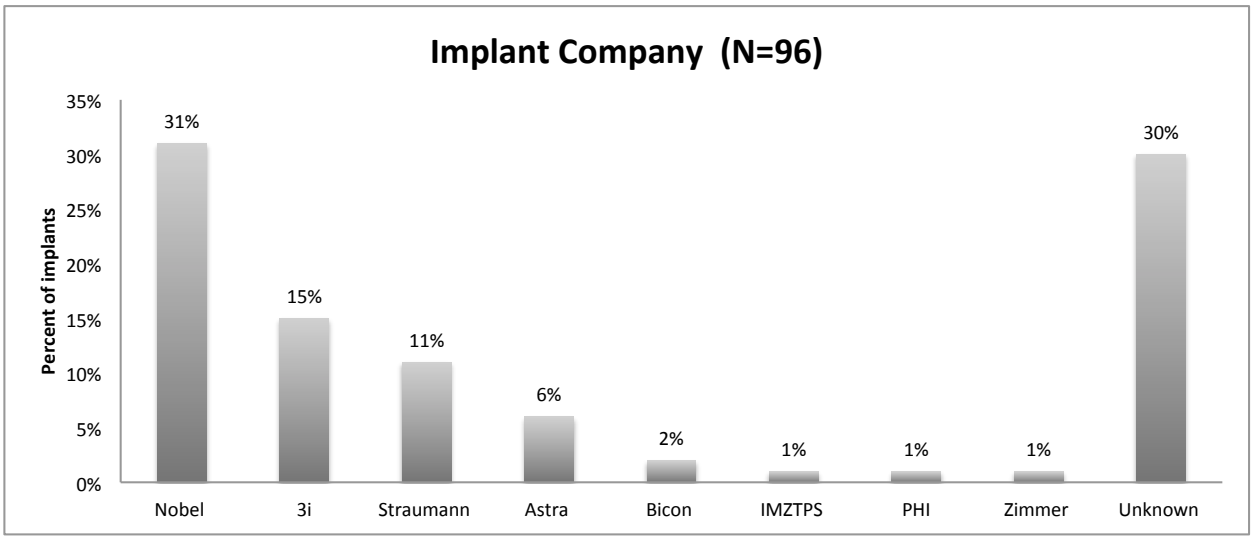

Figure 8: The implant company type that were removed.

Unfortunately, occlusion, types of restorations, and parafunctional habits were not sufficiently discussed in patients' records for analysis.

Periodontal maintenance was reported for 38% patients; whereas 45% documented no regular maintenance (**Figure 9**). Seventeen percent of patients' charts did not report if

maintenance was performed. Of those in maintenance, 23% were on a 6 month recall, 10% on a 4 month recall, and 5% on a 3 month recall (**Figure 10**).

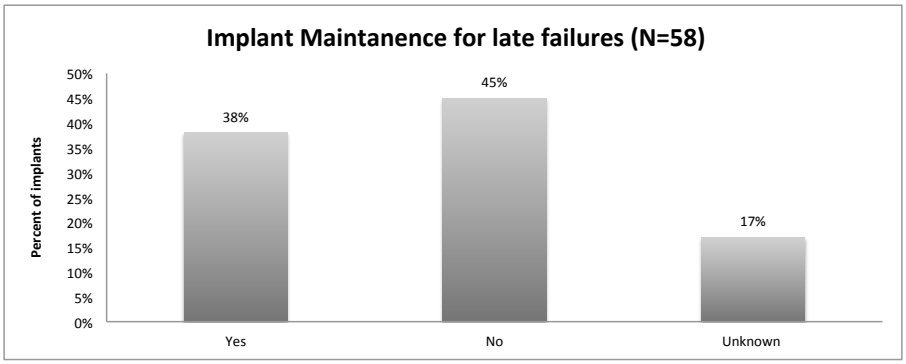

Figure 9: Percent Distribution of dental implants that underwent any kind of maintenance therapy.

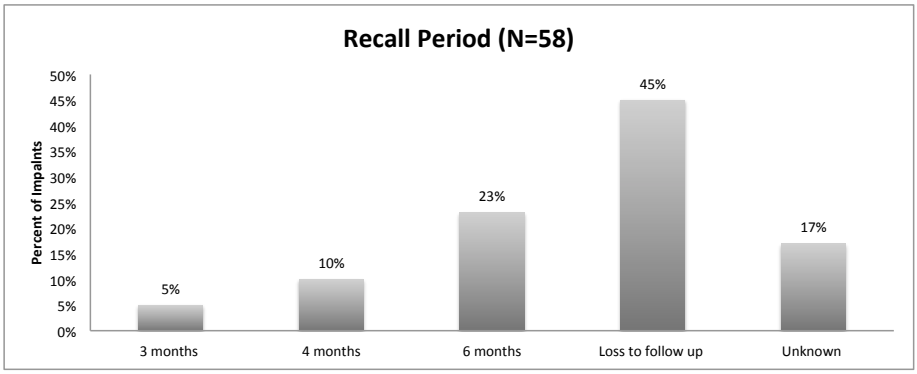

Figure 10: Maintenance regime that was followed for late failure implants

Discussion

Implant failure could be the result of biological or mechanical complications and lead to removal of the fixtures, often leaving the patient in a more compromised position for reconstruction than when they started. The clinician needs to systematically evaluate the patient for the risk of developing such complications and inform the patient of all the risks associated with implant treatment. Therefore, this retrospective study attempted to identify comorbidities in patients that lost implants due to such complications. Patient charts and radiographs were examined for the etiology of the failure. Most cases presented with signs of biological

complications – bleeding on probing, erythema, deep pocketing, and radiographic bone loss. Peri-implantitis is characterized by inflammation in peri - implant connective tissue and progressive loss of supporting bone (Schwarz, 2017). In this study, peri-implantitis was the presumed leading cause of implant removal and, therefore, was used as a surrogate for implant removal in our study for discussion purposes where applicable.

Demographics

The patients included in this study were patients of record at the UCSF Dental Center who had one or more implants removed due to various reasons. Thirty - eight patients were males, 34 were females and 1 transgender (patient on hormonal therapy). Sixteen patients had multiple implants removed, 68% of which were male patients. This compares to a retrospective study in which male gender had a higher association with peri - implant disease (Koldsland, 2011). However, another study showed no significant association between age, gender, and peri - implant disease (Renvert, 2014). The same study showed that older patients also had more systemic diseases, polypharmacy, and a higher prevalence of periodontal disease, which could contribute to a higher failure of dental implants. In our study, the majority of the patients who had to undergo explantation were over 50 years of age. This agrees with a report showing a higher prevalence of implant failures in older populations; especially late implant failure in men (Manor, 2009). Nevertheless, implant failure is a multifactorial disease, and various contributing factors should be considered besides gender.

Medical Conditions

Cardiovascular Disease. In the population examined in this study, 32% of patients had cardiovascular disease, including ischemic heart disease, stroke, and hypertensive heart disease. According to the WHO, cardiovascular disease is one of the most common chronic conditions in

the aging population (WHO, 2015), therefore our patient population is consistent with this report on world norms. A retrospective study by Renvert showed an association of cardiovascular disease with peri - implantitis, reporting the highest odds ratio (11.9) between diagnosis of peri – implantitis and a history of cardiovascular disease. However, a cohort study by Wu (2016) found a decreased failure rate of dental implants in patients who used antihypertensive drugs (0.6%) compared to 4.1% of nonusers. They concluded that various classes of antihypertensive drugs have positive effects on bone remodeling and formation. More studies are needed to evaluate the effect of cardiovascular disease on rate of implant failure.

Bone Disorders. Bone related ailments, such as osteoarthritis, osteoporosis and osteopenia were reported in 23% of patients in this study. In a cross - sectional study, Dvorak et al., did not find a statistically significant association between peri - implantitis or implant loss and diagnosis of osteoporosis or osteopenia (2011). However, in a retrospective study, Alsaadi et al. found an association between osteoporosis and early implant failure (up to abutment connection) (Alsaadi, 2007). A consensus report that used a meta-analysis to evaluate the effect of systemic disease on implant survival post loading, found that patients that received low - dose antiresorptive therapy for osteoporosis and osteoarthritis had comparatively high implant survival rates (Schimmel, 2018). However, patients that received high dose anti-antiresorptive therapy for metastatic cancer treatment and osteoporosis had increased rates of complications. Bisphosphonates that were administered intravenously for metastatic cancer patients, increased the risk of osteonecrosis of the jaw due to their long-lasting inhibitory effects on osteoclast activity (Ruggiero, 2009)

Cancer. In its various forms, cancer was reported in 11% of our patient population. Records were not sufficient to determine the exact timing of cancer diagnosis and treatment in

relation to dental implant procedures. Nevertheless, patients reported chemotherapy and/or radiation therapy as part of their cancer treatment. There is strong evidence showing that head and neck radiation negatively impacts dental implant treatment (Ihde, 2009). Radiation decreases bone remodeling potential and decreases the blood supply to the remodeling bone; both of which can lead to complications if dental surgery is performed (Tanaka, 2003). Due to the increased risk of implant failure and osteonecrosis of the jaw, dental implants are contraindicated for such patients. However, with improvements in cancer treatment, the dosage and scatter of radiation can be decreased, thereby having a more positive effect on post – radiation healing potential. A meta analysis showed an 83% survival rate for implants placed in radiated bone (Schiegnitz, 2014).

Emotional Disorders. Eighteen percent of the studied population reported an emotional disorder, such as anxiety, depression, or post - traumatic stress disorder. The electronic dental records also indicated the use of medications to treat these conditions, such as selective serotonin reuptake inhibitors (SSRIs). In addition to their desired effects, SSRIs can also reduce bone remodeling and increase the risk of bone fractures by influencing signaling pathways in osteoblasts and osteoclasts (Tsapakis, 2012). In a cohort study of 490 patients, a higher risk of late implant failure was reported in SSRI users compared to nonusers (Wu, 2014). A systematic review completed for the ITI Consensus Meeting reported a significantly higher implant failure rate for SSRI users and proton pump inhibitor (PPI) users (Jung, 2018). Taken in aggregate, these data indicate that SSRIs and PPIs could be associated with medication - related implant failures.

Gastrointestinal Acid Related Conditions. Conditions such as peptic ulcers, gastroesophageal reflux disease, or acid reflux were recorded in 16% of the patient population in

the current study. A common class of medications for such conditions are PPIs, which, in addition to modulating gastric acidity, also influence bone metabolism. This class of medications inhibits the H/K ATPase pump, which is present both in the GI tract and bone osteoclasts. In bone osteoclasts, PPIs reduce osteoclast remodeling potential (Ngamruengphong, 2011). Implant survival depends on bone metabolism, so PPIs have been investigated as a risk indicator for peri - implant disease. In a cohort study of PPI users and non-users, Wu et al. followed 799 patients who had dental implants placed. Subjects using PPIs had higher failure rates (6.8%) compared to non-users (3.2%), primarily 10-20 months after implant placement (Wu, 2017). Published data support that PPIs influence bone remodeling, and therefore, PPIs may have adverse effects on implant osseointegration (Mester, 2019).

Diabetes. Ten out of 73 (14%) patients in this study had diabetes, which is higher than the global prevalence of 8.8% (Ogurtsova, 2017). HbA1c values were not available for all patients; however, this is a critical value that can show the level of control of the disease. Monje et al. conducted a systematic review and meta-analysis aimed at investigating the association of hyperglycemia to peri - implant disease (Monje, 2017). This meta - analysis of 7 studies revealed that the risk of peri - implantitis was 50% higher in patients with diabetes (of any severity and with hemoglobin HbA1c levels above 5.7%), compared to healthy controls. In patients with diabetes, the chronic inflammatory state and decreased repair and wound healing of periodontal tissues could adversely affect the health of peri - implant tissues. However, with good glycemic control, osseointegration of dental implants is possible, and implant treatment can have comparable success rates as that in healthy patients (Javed, 2009; Chrcanovic, 2004).

Smoking

Thirty-two percent of the patients in this study were smokers or had a history of using tobacco. The specific form, quantity, and duration of tobacco product usage was not analyzed in this study, due to limited information recorded in the patient records. Previous studies indicate a significant deleterious impact of smoking on implant health (Wallace, 2000). Smoking is believed to have a negative effect on new bone formation by reducing calcium absorption and impairing wound healing through direct toxic effects (Riebel, 1995). In a cross - sectional study of 119 subjects, a high association between implant loss and smoking was reported (Koldsland, 2009). Although, a majority of current studies do not report strong evidence to classify smoking as a risk factor for peri - implantitis (Schwar, 2017); additional long-term studies are needed to shed more light on this topic.

Periodontal Disease

A history of periodontal disease is one of the main risk indicators for peri - implant disease and subsequent implant failure (Schwarz, 2017). Periodontitis occurs in roughly 50% of the adult population in the United States (Eke, 2015). This number is in agreement with the results of the current study, wherein 59% of patients had a history of periodontal treatment and / or had active periodontal disease. A ten - year prospective cohort study by Karoussis et al showed that a history of periodontal disease is associated with lower survival rates for dental implants - 90.5% survival for periodontitis patients versus 96.5% for patients with no history of periodontal disease (Karoussis, 2003). Periodontitis is a bacterial infection, and peri - implant disease shares a common etiology. Bacteria originating from teeth with periodontal disease can infect dental implants, which is important in partially edentulous patients that have remaining deep pockets (Mombelli, 1995). Implants placed in patients with poorly controlled periodontal

disease show higher odds for developing peri – implantitis; from an odds ratio of 5 (Roos-Jansåker, 2006) to an odds ratio of 6 (Koldsland, 2011). Periodontal disease needs to be properly treated and stabilized in order to reduce the risk of peri-implant disease, which could lead to implant failure (Mombelli, 1998).

Infected Recipient Site

Our study found that 6 fixtures were removed from previously failed endodontic sites with noted periapical radiolucencies. A histopathologic study on 154 alveolar bone specimens discovered that bacteria can remain encapsulated in the edentulous alveolar ridge for 1 year or more after extraction and mucosal healing (Kassolis, 2010). These encapsulated bacteria could trigger an infection around the apical portion of the implant (McAllister, 1992). Residual infection could present as retrograde peri - implantitis (RPI), described as a symptomatic periapical lesion with no bone loss or signs of inflammation around the coronal portion of the implant (Quirynen, 2003). Placement of implants in previously infected sites could contribute to implant failure (Esposito, 1998). In contrast, there are several systematic reviews suggesting that immediate implants can be placed in sites having a prior history of periapical lesions with comparable results to those placed in healthy edentulous sites (Crespi, 2010, Chrcanovic, 2015).

Bone Augmentation

Bone augmentation and ridge regeneration are essential components of modern implant dentistry. In this study, out of 96 implants, at least 46 (42.7%) needed augmentation, prior to and/or during implant placement. Various materials and combinations were used; the most common being allograft (54%). Mixtures of allograft with autogenous bone (12%) and with xenograft (10%) were also utilized. Literature strongly supports the benefits of and the necessity for grafting and shows comparable survival rates for implants placed in regenerated versus native

bone (Hämmerle, 2002; Chiapasco, 2009). A review article by Jensen et al. indicates high survival rates for implants placed at sites with horizontal ridge augmentation (97 - 100%), vertical ridge augmentation (95 -100%), and maxillary sinus floor elevation (61.2-100%) (Jensen, 2009). However, the follow-up period in this study was fairly short - 12 months after loading. Some studies suggest that bone augmentation lowers the risk of developing peri - implant disease because implants can be placed in a favorable position in ample amounts of bone (Konstantinidis, 2015; Poli, 2016). On the other hand, there are reports that show a weak association between previous ridge augmentation and peri - implant disease after an 8-year follow (P=0.617) (Busenlechner, 2014). Long-term follow up studies on grafting outcomes would be beneficial.

Early vs Late Failures

Implant failure can be divided into two categories; early failure (before abutment connection), and late failure (after occlusal loading). In the current study, out of 96 implants, 34% implants failed prior to placement of the permanent restoration, and 61% failed after being in function for up to 15 years. The time of failure could not be determined in 5% of the implants because of limited information in patients' charts. Previous studies also reported a greater percentage of late implant loss compared to early implant loss. In a systematic review, Berglundh, et al. determined that early implant loss comprised 0.76-7.47% of the cases and late implant loss comprised 2.1 - 11.3% of the cases (Berglundh, 2002). Some of the proposed contributory factors in early implant failure include, surgical technique, postoperative infection, and inadequate adjustment of prosthetic appliances that can lead to overloading of the fixture and prevention of proper healing (Esposito, 1998). Late failures are associated with peri - implant disease as demonstrated by radiographic bone loss, bleeding on probing, and deepening pocket

depths (Schwartz, 2018). Mechanical failures are also noted, such as restoration or implant fracture (Esposito, 1998).

Occlusion

Although occlusion and patient habits, such as bruxism, have been discussed in only a few cases, they are important factors to consider. Manor et al's review found that improper functional balance was the leading cause of late implant failure (Manor, 2009). Stress concentrations from off axial loading also result in marginal bone loss (Van Steenberghe, 1999). Multiple investigations showed that long cantilevers or parafunctional habits cause significant bone remodeling around dental implants. (Lindquist, 1988; Esposito, 1998). Further, marginal bone loss can cause deepening of pockets around implants and increase the bacterial load, which can lead to significant peri - implant disease and eventual implant failure (Kozlovsky, 2007). Advances in implant dentistry allow placement of tilted implants to avoid vital structures, for additional augmentation procedures, and to potentially increase anterior – posterior spread of the restoration. However, such implants are then loaded off axis, potentially concentrating the stress on the implant (Lan, 2010). A meta analysis on 7,568 implants failed to show a difference in survival rates and marginal bone loss between straight and tilted implants, but there were limitations in the studies, including a fairly short follow up of 3 years and a high bias was noted. Nevertheless, the review discussed the influence of the angle of the tilt on increasing marginal bone loss. A proper restorative design and loading should be accounted for when planning implant placement.

Maintenance

One of the main considerations in dental health is personal oral hygiene. Implant health is especially dependent on adherence to good oral health. Studies show that patients with poor oral

hygiene are more prone to both periodontal and peri – implant disease and complications (Roccuzzo, 2010). Peri - implant mucositis is more likely to progress to peri – implantitis in patients who do not practice proper preventative maintenance (Costa, 2012; Jepsen 2015). Peri – implantitis occurs less in patients who comply with maintenance therapy; odds ratio of 0.14 (Monje, 2017). A cross sectional analysis by Schwarz et al found that high plaque levels were significantly correlated with peri – implantitis; odd radio 9.2 (Schwarz, 20I7) Therefore, regular self and professional maintenance is the key to success for peri - implant health (Schwarz, 2018).

Conclusion

Comprehensive individual risk assessments should be implemented and discussed with each patient planned for implant therapy. Implant failure is multifactorial and highly coincidental with the presence of periodontal disease and other factors, such as bone disorders and cardiovascular disease, and the use of specific medications. Occlusion is an important factor that needs to be considered in failing implants. This area needs to be further explored to determine a potential causal relationship. A holistic approach, which includes careful analysis of systemic conditions, emotional disorders, smoking, and endodontic history, should be practiced.

References

Albrektsson, Tomas, and Lars Sennerby. "State of the art in oral implants." *Journal of clinical periodontology* 18.6 (1991): 474-481.

Alsaadi, Ghada, et al. "Impact of local and systemic factors on the incidence of oral implant failures, up to abutment connection." *Journal of clinical periodontology* 34.7 (2007): 610-617.

Berglundh, Tord, Leif Persson, and Björn Klinge. "A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years." *Journal of clinical periodontology* 29 (2002): 197-212.

Berglundh, Tord, et al. "De novo alveolar bone formation adjacent to endosseous implants: a model study in the dog." *Clinical oral implants research* 14.3 (2003): 251-262.

Brånemark, P-I., et al. "Intra-osseous anchorage of dental prostheses: I. Experimental studies." *Scandinavian journal of plastic and reconstructive surgery* 3.2 (1969): 81-100.

Busenlechner, Dieter, et al. "Long-term implant success at the Academy for Oral Implantology: 8-year follow-up and risk factor analysis." *Journal of periodontal & implant science* 44.3 (2014): 102-108.

Chiapasco, Matteo, Paolo Casentini, and Marco Zaniboni. "Bone augmentation procedures in implant dentistry." *Int J Oral Maxillofac Implants* 24.Suppl (2009): 237-259.

Chrcanovic, B. R., Tomas Albrektsson, and Ann Wennerberg. "Diabetes and oral implant failure: a systematic review." *Journal of dental research* 93.9 (2014): 859-867.

Chrcanovic, Bruno Ramos, Maximiliano Delany Martins, and Ann Wennerberg. "Immediate placement of implants into infected sites: a systematic review." *Clinical implant dentistry and related research* 17 (2015): e1-e16.

Costa, Fernando Oliveira, et al. "Peri-implant disease in subjects with and without preventive maintenance: a 5-year follow-up." *Journal of clinical periodontology* 39.2 (2012): 173-181.

Crespi, Roberto, Paolo Capparè, and Enrico Gherlone. "A 4-year evaluation of the peri-implant parameters of immediately loaded implants placed in fresh extraction sockets." *Journal of periodontology* 81.11 (2010): 1629-1634.

Dvorak, Gabriella, et al. "Peri-implantitis and late implant failures in postmenopausal women: a cross-sectional study." *Journal of clinical periodontology* 38.10 (2011): 950-955.

Eke, Paul I., et al. "Update on prevalence of periodontitis in adults in the United States: NHANES 2009 to 2012." *Journal of periodontology* 86.5 (2015): 611-622.

Esposito, Marco, et al. "Biological factors contributing to failures of osseointegrated oral implants,(II). Etiopathogenesis." *European journal of oral sciences* 106.3 (1998): 721-764.

Fugazzotto, Paul A. "A comparison of the success of root resected molars and molar position implants in function in a private practice: results of up to 15-plus years." *Journal of periodontology* 72.8 (2001): 1113-1123.

Hämmerle, Christoph HF, Ronald E. Jung, and Andreas Feloutzis. "A systematic review of the survival of implants in bone sites augmented with barrier membranes (guided bone

regeneration) in partially edentulous patients." *Journal of clinical periodontology* 29 (2002): 226-231.

Heitz-Mayfield, Lisa JA. "Peri-implant diseases: diagnosis and risk indicators." *Journal of clinical periodontology* 35 (2008): 292-304.

Ihde, Stefan, et al. "Effects of radiation therapy on craniofacial and dental implants: a review of the literature." *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 107.1 (2009): 56-65.

Javed, Fawad, and George E. Romanos. "Impact of diabetes mellitus and glycemic control on the osseointegration of dental implants: a systematic literature review." *Journal of periodontology* 80.11 (2009): 1719-1730.

Jepsen, Søren, et al. "Primary prevention of peri-implantitis: Managing peri-implant mucositis." *Journal of clinical periodontology* 42 (2015): S152-S157.

Jensen, S. Storgard, and Hendrik Terheyden. "Bone augmentation procedures in localized defects in the alveolar ridge: clinical results with different bone grafts and bone-substitute materials." *Database of Abstracts of Reviews of Effects (DARE): Quality-Assessed Reviews [Internet]*. Centre for Reviews and Dissemination (UK), 2009.

Jung, Ronald E., et al. "Group 1 ITI Consensus Report: The influence of implant length and design and medications on clinical and patient-reported outcomes." *Clinical oral implants research* 29 (2018): 69-77.

Karoussis, Ioannis K., et al. "Long-term implant prognosis in patients with and without a history of chronic periodontitis: a 10-year prospective cohort study of the ITI® Dental Implant System." *Clinical oral implants research* 14.3 (2003): 329-339.

Karoussis, Ioannis K., Sotirios Kotsovilis, and Ioannis Fourmousis. "A comprehensive and critical review of dental implant prognosis in periodontally compromised partially edentulous patients." *Clinical oral implants research* 18.6 (2007): 669-679.

Kassolis, James D., et al. "Histopathologic findings in bone from edentulous alveolar ridges: a role in osteonecrosis of the jaws?." *Bone* 47.1 (2010): 127-130.

Koldsland, Odd Carsten, Anne Aamdal Scheie, and Anne Merete Aass. "Prevalence of implant loss and the influence of associated factors." *Journal of periodontology* 80.7 (2009): 1069-1075.

Koldsland, Odd Carsten, Anne Aamdal Scheie, and Anne Merete Aass. "The association between selected risk indicators and severity of peri-implantitis using mixed model analyses." *Journal of clinical periodontology* 38.3 (2011): 285-292.

Konstantinidis, Ioannis K., et al. "Cross-sectional study on the prevalence and risk indicators of peri-implant diseases." *Eur J Oral Implantol* 8.1 (2015): 75-88.

Kozlovsky, Avital, et al. "Impact of implant overloading on the peri-implant bone in inflamed and non-inflamed peri-implant mucosa." *Clinical oral implants research* 18.5 (2007): 601-610.

Lan, Ting-Hsun, et al. "Bone stress analysis of various angulations of mesiodistal implants with splinted crowns in the posterior mandible: a three-dimensional finite element study." *International Journal of Oral & Maxillofacial Implants* 25.4 (2010).

Lang, Niklaus P., Tord Berglundh, and Working Group 4 of the Seventh European Workshop on Periodontology. "Periimplant diseases: where are we now?–Consensus of the Seventh

European Workshop on Periodontology." *Journal of clinical periodontology* 38 (2011): 178-181.

Lindquist, Lars W., Birger Rockler, and Gunnar E. Carlsson. "Bone resorption around fixtures in edentulous patients treated with mandibular fixed tissue-integrated prostheses." *The Journal of prosthetic dentistry* 59.1 (1988): 59-63.

Manor, Yifat, et al. "Characteristics of early versus late implant failure: a retrospective study." *Journal of Oral and Maxillofacial Surgery* 67.12 (2009): 2649-2652.

McAllister, B. S., D. Masters, and R. M. Meffert. "Treatment of implants demonstrating periapical radiolucencies." *Practical periodontics and aesthetic dentistry: PPAD* 4.9 (1992): 37-41.

Mester, Alexandru, et al. "The impact of proton pump inhibitors on bone regeneration and implant osseointegration." *Drug metabolism reviews* 51.3 (2019): 330-339.

Meyer, Simon, et al. "Experimental mucositis and experimental gingivitis in persons aged 70 or over. Clinical and biological responses." *Clinical oral implants research* 28.8 (2017): 1005-1012.

Moraschini, V., et al. "Evaluation of survival and success rates of dental implants reported in longitudinal studies with a follow-up period of at least 10 years: a systematic review." *International journal of oral and maxillofacial surgery* 44.3 (2015): 377-388.

Mombelli, A., et al. "The microbiota associated with successful or failing osseointegrated titanium implants." *Oral microbiology and immunology* 2.4 (1987): 145-151.

Mombelli, Andrea, and Niklaus P. Lang. "The diagnosis and treatment of peri-implantitis." *Periodontology 2000* 17.1 (1998): 63-76.

Monje, Alberto, Andres Catena, and Wenche S. Borgnakke. "Association between diabetes mellitus/hyperglycaemia and peri-implant diseases: Systematic review and meta-analysis." *Journal of clinical periodontology* 44.6 (2017): 636-648.

Monje, Alberto, Hom-Lay Wang, and José Nart. "Association of preventive maintenance therapy compliance and peri-implant diseases: a cross-sectional study." *Journal of periodontology* 88.10 (2017): 1030-1041.

Ngamruengphong, Saowanee, et al. "Proton pump inhibitors and risk of fracture: a systematic review and meta-analysis of observational studies." *American Journal of Gastroenterology*106.7 (2011): 1209-1218.

Ogurtsova, Katherine, et al. "IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040." *Diabetes research and clinical practice* 128 (2017): 40-50.

Pjetursson, Bjarni E., et al. "A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years: I. Implant-supported FPDs." *Clinical oral implants research* 15.6 (2004): 625-642.

Poli, Pier Paolo, et al. "Risk indicators related to peri-implant disease: an observational retrospective cohort study." *Journal of periodontal & implant science* 46.4 (2016): 266-276.

Quirynen, Marc, Frieda Gijbels, and Reinhilde Jacobs. "An infected jawbone site compromising successful osseointegration." *Periodontology 2000* 33.1 (2003): 129-144.

Renvert, Stefan, et al. "Factors related to peri-implantitis–a retrospective study." *Clinical oral implants research* 25.4 (2014): 522-529.

Riebel, Gregory D., et al. "The effect of nicotine on incorporation of cancellous bone graft in an animal model." *Spine* 20.20 (1995): 2198-2202.

Roccuzzo, Mario, et al. "Ten-year results of a three-arm prospective cohort study on implants in periodontally compromised patients. Part 1: implant loss and radiographic bone loss." *Clinical Oral Implants Research* 21.5 (2010): 490-496.

Roos-Jansåker, Ann Marie, et al. "Nine-to fourteen-year follow-up of implant treatment. Part I: implant loss and associations to various factors." *Journal of clinical periodontology* 33.4 (2006): 283-289.

Ruggiero, Salvatore L., et al. "American Association of Oral and Maxillofacial Surgeons position paper on bisphosphonate-related osteonecrosis of the jaws—2009 update." *Journal of Oral and Maxillofacial Surgery* 67.5 (2009): 2-12.

Salvi, Giovanni E., et al. "Reversibility of experimental peri-implant mucositis compared with experimental gingivitis in humans." *Clinical oral implants research* 23.2 (2012): 182-190.

Schiegnitz, E., et al. "Oral rehabilitation with dental implants in irradiated patients: a meta-analysis on implant survival." *Clinical oral investigations* 18.3 (2014): 687-698.

Schimmel, Martin, et al. "Effect of advanced age and/or systemic medical conditions on dental implant survival: A systematic review and meta-analysis." *Clinical oral implants research* 29 (2018): 311-330.

Schwarz, Frank, et al. "The prevalence of peri-implant diseases for two-piece implants with an internal tube-in-tube connection: a cross-sectional analysis of 512 implants." *Clinical oral implants research* 28.1 (2017): 24-28.

Schwarz, Frank, et al. "Peri-implantitis." *Journal of clinical periodontology* 45 (2018): S246-S266.

Tanaka, Takako Imai, et al. "Updated clinical considerations for dental implant therapy in irradiated head and neck cancer patients." *Journal of Prosthodontics* 22.6 (2013): 432-438.

Tsapakis, E. M., et al. "The adverse skeletal effects of selective serotonin reuptake inhibitors." *European psychiatry*27.3 (2012): 156-169.

Van Steenberghe, Daniel, et al. "Influence of inflammatory reactions vs. occlusal loading on peri-implant marginal bone level." *Advances in dental research* 13.1 (1999): 130-135.

Wallace, Robert H. "The relationship between cigarette smoking and dental implant failure." *The European journal of prosthodontics and restorative dentistry* 8.3 (2000): 103-106.

World Health Organization. *World report on ageing and health*. World Health Organization, 2015.

Wu, X., et al. "Selective serotonin reuptake inhibitors and the risk of osseointegrated implant failure: a cohort study." *Journal of dental research* 93.11 (2014): 1054-1061.

Wu, Xixi, et al. "Antihypertensive medications and the survival rate of osseointegrated dental implants: a cohort study." *Clinical implant dentistry and related research* 18.6 (2016): 1171-1182.

Wu, Xixi, et al. "Proton pump inhibitors and the risk of osseointegrated dental implant failure: a cohort study." *Clinical implant dentistry and related research* 19.2 (2017): 222-232.

Publishing Agreement

It is the policy of the University to encourage open access and broad distribution of all theses, dissertations, and manuscripts. The Graduate Division will facilitate the distribution of UCSF theses, dissertations, and manuscripts to the UCSF Library for open access and distribution. UCSF will make such theses, dissertations, and manuscripts accessible to the public and will take reasonable steps to preserve these works in perpetuity.

I hereby grant the non-exclusive, perpetual right to The Regents of the University of California to reproduce, publicly display, distribute, preserve, and publish copies of my thesis, dissertation, or manuscript in any form or media, now existing or later derived, including access online for teaching, research, and public service purposes.

DocuSigned by:
Anastasiya Petrovska
38B124D71E834BE...
Author Signature

5/24/2020
Date